III. Hazard Analysis

Introduction

This Chapter of the Plan answers the question: *What kinds of natural hazards can affect the State of New Hampshire?* As previously mentioned in Chapter II, a great deal of research was conducted to accurately answer this question. In addition to research, the State Hazard Mitigation Planning Committee (SHMPC) helped to identify the hazards that have or could occur in the State. As a result the SHMPC determined that the State Mitigation Plan needed to address the risks associated with the following hazards:

Flooding
Coastal Flooding
Dam Failure
Drought
Wildfire
Earthquake
Landslide
Radon
Tornado/Downburst
Hurricane
Lightning
Severe Winter Weather
Snow Avalanche

The narrative following each natural hazard is examined in three parts, including: a general description, historical events and geographical extent. The table below provides a summary of previous occurrences and severity of the hazards.

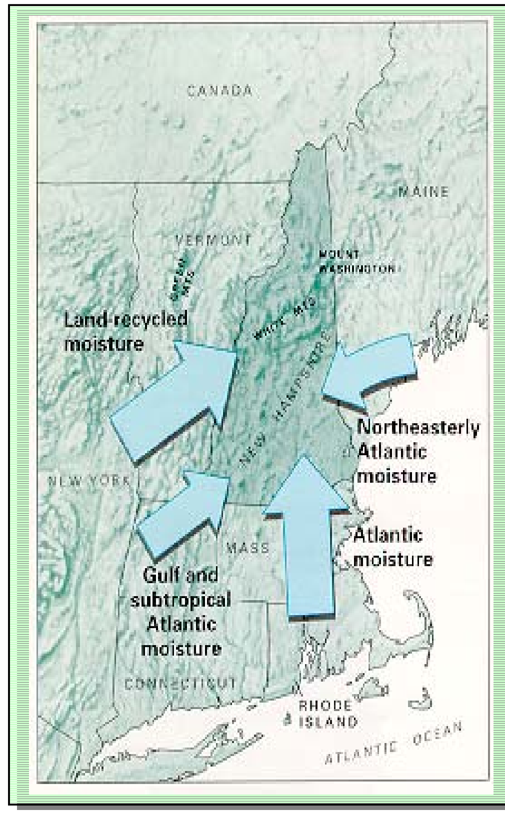
Hazard	Frequency	Severity
Flooding	**High**	**High**
Costal Flooding	Moderate	Moderate
Dam Failure	*Low*	Moderate
Drought	*Low*	Moderate
Wildfire	**High**	*Low*
Earthquake	*Low*	*Low*
Landslide	*Low*	*Low*
Radon	Moderate	*Low*
Tornado/Downburst	Moderate	Moderate
Hurricane	Moderate	**High**
Lightning	Moderate	*Low*
Severe Winter Weather	**High**	**High**
Snow Avalanche	*Low*	*Low*

STATE OF NEW HAMPSHIRE *Presidentially Declared Disasters (DR) & Emergency Declarations (EM) 1982 to 2004*					
Date Declared	**Event Type**	**FEMA Disaster #**	**Program(s)**	**Dollar Amount**	**Counties Declared**
August 27, 1986	Severe Storms/Flooding	FEMA-771-DR	PA	1,005,000	Cheshire & Hillsborough
April 16, 1987	Severe Storms/Flooding	FEMA-789-DR	PA/IA	4,888,889	Cheshire, Carroll, Grafton, Hillsborough Merrimack, Rockingham & Sullivan
August 29, 1990	Severe Storms/Winds	FEMA-876-DR	PA	2,297,777	Belknap, Carroll, Cheshire, Coos, Grafton, Hillsborough, Merrimack & Sullivan
September 9, 1991	Hurricane	FEMA-917-DR	PA	2,293,449	Statewide
November 13, 1991	Coastal Storm/Flooding	FEMA-923-DR	PA/IA	1,500,000	Rockingham
March 16, 1993	Heavy Snow	FEMA-3101-EM	PA	832,396	Statewide
January 3, 1996	Storms/Floods	FEMA-1077-DR	PA	2,220,384	Carroll, Cheshire, Coos, Grafton, Merrimack & Sullivan
October 29, 1996	Severe Storms/Flooding	FEMA-1144-DR	PA	2,341,273	Grafton, Hillsborough, Merrimack, Rockingham, Strafford & Sullivan,
January 15, 1998	Ice Storm	FEMA-1199-DR	PA/IA	12,446,202	Belknap, Carroll, Cheshire, Coos, Grafton, Hillsborough, Merrimack, Strafford, Sullivan
July 2, 1998	Severe Storms	FEMA-1231-DR	PA/IA	3,420,120	Belknap, Carroll, Grafton, Merrimack, Rockingham & Sullivan
October 18, 1999	Hurricane/Tropical Storm Floyd	FEMA-1305-DR	PA	750,133	Grafton, Belknap and Cheshire
March 2001	Snow Emergency	FEMA-3166-EM	PA	4,500,000	Cheshire, Coos, Grafton, Hillsborough, Merrimack, Rockingham, and Strafford
February 17-18, 2003	Snow Emergency	FEMA-3177-EM	PA	3,000,000	Cheshire, Hillsborough, Merrimack, Rockingham & Strafford
September 12, 2003	Severe storms & flooding	FEMA-1489-DR	PA	1,300,00	Cheshire & Sullivan
March 11, 2003	Snow Emergency	FEMA-3177-EM	PA	3,000,000	Cheshire, Hillsborough, Merrimack, Rockingham & Strafford
January 15, 2004	Snow Emergency	FEMA-3193-EM	PA	3,200,000	Belknap, Carroll, Cheshire, Coos, Grafton, Hillsborough, Merrimack & Sullivan
16 Declarations Totaling $47,696,923					

A. Flooding

General Description

New Hampshire has more than 16,000 miles of rivers and streams and the State's settlement pattern is confluent with these locations. Communities developed along the waterways that provided mills with power and transportation. As a result of this development pattern, the floodplains of the State were rapidly settled. The shift to industrialization during the mid-nineteenth century compounded the problem, residents moved to the floodplains of the cities and larger villages. Such encroachment has lead to flooding problems, as the floodplains are extensions of the watercourses and evolved to carry excessive runoffs naturally. General flooding is also caused by major hurricanes that follow the coast as well as those that track inland. Significant flooding occurs periodically along the watercourses with resultant loss of lives and property.



(From USGS Water Supply Paper 2375)

New Hampshire has a climate of abundant precipitation. Weather ranges from moderate coastal to severe continental, with annual precipitation ranging from about 35 inches in the Connecticut and Merrimack River valleys, to about 90 inches on top of Mount Washington. Localized street flooding occasionally results from severe thundershowers, or over larger areas, from more general rain such as tropical cyclones and coastal "northeasters." More general and disastrous floods are rare but some occur in the spring from large rainfall quantities combined with warm, humid winds that rapidly release water from the snowpack.[1]

Riverine Flooding is the most common disaster event in the State of New Hampshire. Significant riverine flooding impacts upon some areas in the State in less than ten year intervals. (See the Table of Major Disasters and NH Flood History.)

Total NFIP Policies	Total Amount of Claims Paid Since 1978	Total Repetitive Loss Properties
4885	**1879 policies paid $9,184,364**	**37 towns with 96 repetitive loss properties 225 total losses**
See map at end of Chapter for geographical display of these figures.		

Flooding in New Hampshire is caused by several different reasons including:

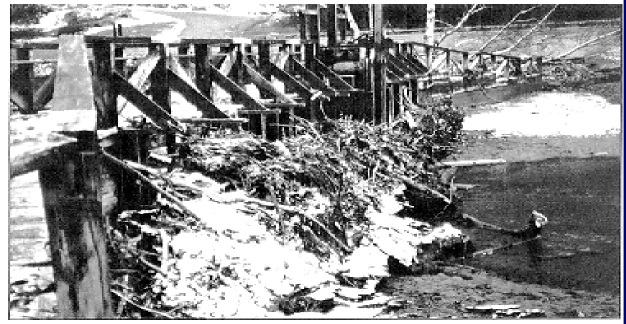
- Debris Impacted Infrastructure
- Erosion and Scouring
- Rapid Snowpack Melt
- River Ice
- Coastal Storm (See also Hurricane Section; Coastal Storms)

Each of these causes are discussed below.

[1] Text reprinted from the Pemigewasset Flood Mitigation Project with permission of Ray Wenninger, P.E.

Debris Impacted Infrastructure

As can be seen from the photo to the right, debris carried by floodwaters can significantly compromise the effectiveness of otherwise adequately designed bridges, dams, culverts, diverting structures etc. Storm debris carried by floodwaters, may exacerbate a given flooding hazard by becoming obstructions to normal stormwater flow (as seen in picture to right).



Willey House Dam, Hart's Location
Upstream Debris Carried to Dam by Floodwaters

Photo from DR-1077-NH

Per the Inter-Agency Hazard Mitigation Team Meeting from FEMA DR-1077-NH, a project was designed to educate the public as to the dimensions of this problem. The Pemigewasset River Corridor Stewardship Program includes the cooperation with NHDES Wetlands Bureau to develop *Best Management Practices* to facilitate river corridor stewardship (i.e., stream bank maintenance and the development of stream maintenance plans.) A more detailed description of this program is located in Chapter V.

Stream Bank Erosion and Scouring

Scouring is a significant problem in New Hampshire, especially along the State's watercourses in the higher elevations that tend to be "flashy" in terms of the flooding experienced.

Pictured here is a location on the Moose River in Gorham. As can be seen from the photos, the railway bridge, railway and rail bed are threatened and stormwater drainage pipes have been uncovered by the scouring. What is not apparent from these photos is the threat to the community's only Fire Station / Emergency Operations Center. The Fire Station lies just downstream of the rail bed in the floodplain.

Typically in New Hampshire the land along such rivers is heavily developed and this site is no exception. Primary State Routes 2 and 16 parallel the railway at this location, only a few hundred yards downstream of this site.

Short Term Mitigation Measures

Riprap has been installed at this site but, given the threat to the Fire Station/EOC, the State Highway and residents nearby, other measures may be indicated.

Rapid Snowmelt

The State's climate, mountainous terrain and riverine watersheds are susceptible to flooding which may be accelerated by the seasonal rapid melting of the snowpack coupled with moderate temperatures and heavy rains. The upland areas may be exposed to flash- flood incidents with associated erosion and deposition issues in or near streambeds.

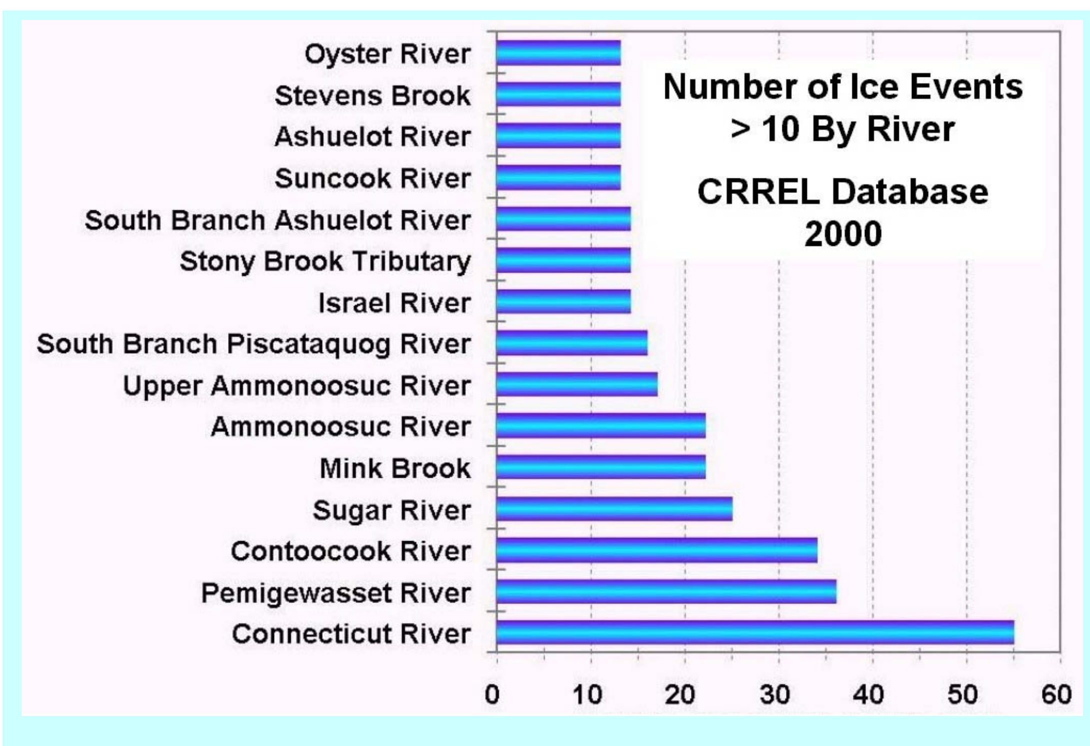
The lower lying areas of the State may experience either flash flooding or inundation events accelerated by the rapid melting of the snowpack.

Peabody River, Gorham, NH – Rapid Snow-pack flooding

Ice Jam Flooding

Ice forming in riverbeds and against structures often presents significant hazardous conditions for many communities in the State. Meltwater and/or stormwaters may then encounter these ice formations, a situation which may tend to apply lateral and/or vertical force upon structures. Moving ice may scour abutments and riverbanks. Ice may also create temporary dams. These dams may create flood hazard conditions where none previously existed.

The State's exposure to this hazard type has prompted several interventions in NH by the U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory (CRREL). The Corps has constructed dams and ice diversion structures to arrest the flow of large, potentially damaging ice formations in order to reduce flooding potential and the possible impact by ice on bridges and other structures. Mitigation measures include, excavation, mechanical breaking, ice blasting, over-spraying an area with ash or leaf mulch to accelerate melting, planned releases of relatively warmer water from impoundments and the installation of electronic devices to signal ice movement which might aid in evacuations and other response measures.



New Hampshire's Flood History

Date	Area Effected (River Basins or Region)	Recurrence interval (yr)	Remarks
December 1740	Merrimack	Unknown	First recorded flood in New Hampshire
October 23, 1785	Cocheco, Baker, Pemigewasset, Contoocook and Merrimack	Unknown	Greatest discharge at Merrimack and at Lowell, Mass. Through 1902
March 24-30, 1826	Pemigewasset, Merrimack, Contoocook, Blackwater and Ashuelot	Unknown	and at Lowell, Mass. Through 1902 and at Lowell, Mass. Through 1902
April 21-24, 1852	Pemigewasset, Winnespaukee, Contoocook, Blackwater, and Ashuelot	Unknown	Merrimack River at Concord; highest stream stage for 70 years. Merrimack River at Nashua,; 2 feet lower than 1785
April 19-22, 1862	Contoocook, Merrimack, Piscataquog, and Connecticut	Unknown	Highest stream stages to date on the Connecticut River; due solely to snowmelt
October 3-5, 1869	Androscoggin, Pemigewasset, Baker, Contoocook, Merrimack, Piscataquog, Soughegan, Ammonoosuc, Mascoma, and Connecticut	Unknown	Tropical storm lasting 36 hours. Rainfall, 6-12 inches
November 3-4, 1927	Pemigewasset, Baker, Merrimack, Ammonoosuc and Connecticut	25 to > 50	Upper Pemigewasset River and Baker River; exceeded the 1936 Flood. Down stream at Plymouth; less severe than 1936 flood
March 11-21, 1936	Statewide	25 to > 50	Double flood; first due to rains and snowmelt; second, due to large rainfall
September 21, 1938	Statewide	Unknown	Hurricane. Stream stages similar to those of March 1936 and exceeded 1936 stages in Upper Contoocook River
June 1942	Merrimack River Basin	Unknown	This was the fourth flood in the lower Merrimack River basin at Manchester, NH
June 15-16,1943	Upper Connecticut, Diamond and Androscoggin	25 to >50	Intense rain exceeding 4 inches; highest stream stages of record in parts of the effected area
June 1944	Merrimack River	Unknown	This was one of the five highest known floods at Manchester on the Merrimack
November 1950	Contoocook River and Nubanusit Brook	Unknown	Localized storm resulted in flooding of this area.
March 27, 1953	Lower Androscoggin, Saco, Ossipee, Upper Ammonoosuc Israel, and Ammonoosuc	25 to > 50	Peak of record for the Saco and Ossipee Rivers.
August 1955	Connecticut River Basin	Unknown	Heavy rains caused extensive damage throughout the basin area
October 25, 1959	White Mountain Area; Saco, Upper Pemigewasset and Ammonoosuc Rivers	25 to > 50	Largest of record on Ammonoosuc at Bethlehem Junctions; third largest of record on the Pemigewasset and Saco Rivers
December 1959	Piscataquog - Portsmouth	Unknown	A Northeaster brought tides exceeding maximum tidal flood levels in Portsmouth. Damage was heavy along the coast
April 1960	Merrimack and Piscataquog	Unknown	Flooding resulted from rapid melting of deep snow covering and the moderate to heavy rainfall. This was the third highest flood of record on the rivers
April 1969	Merrimack River Basin	Unknown	A record depth of snow cover in the Merrimack River Basin and elsewhere resulted in excessive snowmelt and runoff when combined with sporadic rainfall

New Hampshire's Flood History (continued)

Date	Area Effected (River Basins or Region)	Recurrence Interval(yr)	Remarks
February 1972	Coastal Area	Unknown	The **Coastal Area was declared a National Disaster Area** as a result of the devastating effects of a severe coastal storm, damage was extensive
June 1972	Pemigewasset River	Unknown	Five days of heavy rain caused some of the worst flooding since 1927 along streams in the upper part of the State, damage was extensive along the Pemigewasset River and smaller streams in northern areas
June 30, 1973	Ammonoosuc River	25 to > 50	Northwestern White Mountains
April 1976	Connecticut River	Unknown	Rain and snowmelt brought the river to 1972 levels, flooding roads and croplands.
March 14, 1977	South-central and Coastal New Hampshire	25 to 50	Peak of record for Soucook River
February 1978 ("The Blizzard of '78)	Coastal New Hampshire	Unknown	A Nor'easter brought strong winds and precipitation to the entire state. Hardest hit area was the coastline, with wave action and floodwaters destroying homes. Roads all along the coast were breached by waves flooding over to meet the rising tidal waters in the marshes
July 1986 – August 10, 1986	Statewide	Unknown	Severe summer storms with heavy rains, tornadoes; flash flood and severe winds. **FEMA DR-771-NH**
March 31 to April 2, 1987	Androscoggin, Saco, Ossipee, Piscataquog, Pemigewasset, Merrimack & Contoocook River	25 to > 50	Caused by snowmelt and intense rain Precursor to a significant, following event
April 6-7, 1987	Lamprey River and Beaver Brook	25 to > 50	Large rainfall quantities following the March 31- April 2 storm. **FEMA DR-789-NH**
August 7-11, 1990	Statewide	Unknown	A series of storm events from August 7-11, 1990 with moderate to heavy rains during this period produced widespread flooding. **FEMA DR-876-NH**
August 19, 1991	Statewide	Unknown	Hurricane Bob struck New Hampshire causing extensive damage in Rockingham and Stafford counties, but the effects were felt statewide. ***FEMA DR-917-NH***
October 1996	Northern and Western Regions	Unknown	Counties Declared: Carroll, Cheshire, Coos, Grafton, Merrimack, and Sullivan. **FEMA DR-1077-NH**
October – November 1995	Northern and Western Regions	Unknown	Counties Declared: Grafton, Hillsborough, Merrimack, Rockingham, Strafford & Sullivan. **FEMA DR-1144-NH**
June – July 1998	Central and Southern Regions	Unknown	Series of rainfall events. Counties Declared: Belknap, Grafton, Carroll, Merrimack, Rockingham and Sullivan. (1 fatality) (See page 27 - 28) (Several weeks earlier, significant flooding, due to rain and rapid snowpack melting, occurred in Coos county, undeclared in this event. Heavy damage to secondary roads occurred) ***FEMA DR-1231-NH***
September 18 - 19, 1999	Central and Southwest Regions	Unknown	**FEMA DR-1305-NH:** Heavy rains associated with Tropical Storm/Hurricane Floyd. Counties Designated: Belknap, Cheshire and Grafton.
July 21 – August 18, 2003	Southwestern Region	Unknown	**FEMA-1489-DR:** Severe Storms and Flooding occurred in Cheshire and Sullivan counties. Public Assistance provided for repair of disaster damaged facilities.

B Coastal Flooding

General Description

The flooding of low-lying areas on the New Hampshire coast is a natural phenomenon and has occurred for centuries. Coastal flooding in the region primarily occurs due to major rain storms and nor'easters with the added combination of full moon tides causing storm surge and wave effects.

In some areas, human activities, particularly disruption of natural protective coastal features (e.g. dunes or wetlands) or the lowering of land as a consequence of drainage, may also have aggravated the coastal flooding hazard.

The potential impact of predicted, human-induced global warming might also aggravate existing coastal flooding hazard in the future, particularly through an acceleration in the rate of rise of mean sea level and possible changes in the nature, frequency and magnitude of coastal storms.

Some of the more notable coastal storms include:

- ***December 1959:*** A Northeaster brought tides exceeding maximum tidal flood levels in Portsmouth. Damage was heaviest along the coast.
- ***February 1972:*** The **Coastal Area was declared a National Disaster Area** as a result of the devastating effects of a severe coastal storm. Damage was extensive along the coast.
- ***February 1978 ("The Blizzard of '78):*** A Nor'easter brought strong winds and precipitation to the entire state. Hardest hit area was the coastline, with wave action and floodwaters destroying homes. Roads all along the coast were breached by waves flooding over to meet the rising tidal waters in the marshes**.**

Blizzard of '78 – Hampton, NH

C. Dam Failure

General Description

The Department of Environmental Services (DES), through its Dam Bureau, is responsible for the regulation of the state's dams to ensure that they are constructed, maintained and operated in a manner to promote public safety. In practice, these parameters are monitored through dam construction and reconstruction permitting and the regular inspection of all dams that pose a hazard to downstream lives or property.

Dam failures resulting in notable downstream damages are uncommon in New Hampshire, though damages to dams themselves are less so. Frequently an outside catalyst, like an unusually heavy rain event or rain events that occur in conjunction with runoff produced during the spring thaw, serves to stress a dam beyond its design capabilities. An example would be if a storm event produced more runoff than a dam's outlet works (spillways and gates, etc…) could pass. In such cases, the dam will likely be overtopped, that is, have water flow over or through areas that are not designed to serve in such a manner. This condition generally leads to damage to or complete failure of the dam.

Dams can also fail due to poor design and/or construction, as well as due to poor or inadequate maintenance. These types of failures are even less common than event-based failures, which may be the result of the generally high degree of dam owner stewardship and the state's permitting regulations and periodic inspection program. Some notable failures have occurred, however, and information related to them is provided below.

Significant Historical Events:

Abeniki Lake Dam, Dixville, NH
Year: 1960
Hazard Classification: Significant
Cause of Failure: Non-overtopping embankment (slough/slide) failure

Nash Bog Pond, Odell, NH
Date: May 20, 1969
Hazard Classification: Significant
Cause of Failure: Non-overtopping failure of the rock-filled timber crib spillway

Nash Bog Pond

Cold Brook Pond Dam, Lempster, NH
Year: October 21, 1996
Hazard Classification: Significant
Cause of Failure: Progressive (and complete) erosion of the vegetated emergency spillway

Cold Brook Pond

Meadow Pond Dam, Alton, NH
Year: March 12, 1996
Hazard Classification: Significant
Cause of Failure: Non-overtopping embankment piping (internal erosion) failure

Meadow Pond Dam, Alton, NH

Rt. 140 - Downstream

Ox Bow Campground Dam, Hillsborough, NH
Year: April 6, 2004
Hazard Classification: Non-hazardous
Cause of Failure: Overtopping embankment failure

Ox Bow Campground Dam

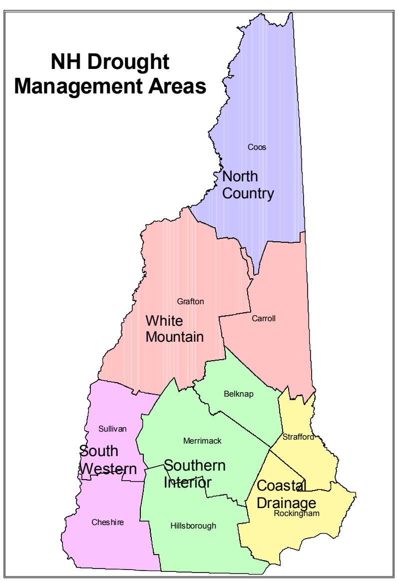
D. Drought

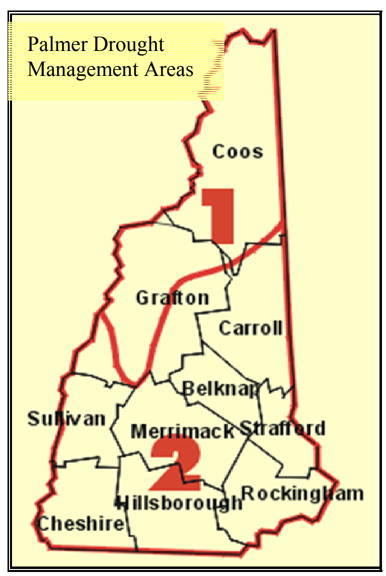
General Description

Droughts are generally not as damaging or disruptive as floods, but are more difficult to define. A drought is a natural hazard that evolves over months or even years and can last as long as several years to as short as a few months, fortunately droughts are rare in New Hampshire. The central theme in the definition of a drought is the concept of water deficit. The severity of the drought is gauged by the degree of moisture deficiency, its duration and the size of the area affected. The effect of droughts, or decreased precipitation, is indicated through measurements of soil moisture, groundwater levels, and streamflow. Not all of these indicators will be minimal during a particular drought. For example, frequent minor rainstorms can replenish the soil moisture without raising ground water levels or increasing streamflow.

Low stream flow correlates with low ground water level because it is ground water discharge to streams and rivers that maintain streamflow during extended dry periods. Low streamflow and low ground water levels commonly cause diminished water supply.

New Hampshire breaks the State into five Drought Management Areas, with one in the north, one across the central region, and three along the southern portion of the State. The National Oceanic and Atmospheric Administration (NOAA) and the US Government, utilize the Palmer Drought Survey Index for conditions of the Nation. The Palmer Drought Management areas divide the State into two areas and utilize the Palmer Drought Severity Index which is based on rainfall, temperature and historic data. The New Hampshire Drought Management Team, the efforts of which are coordinated by the NH DES Dam Bureau, utilizes these maps to help determine which areas are hardest hit.

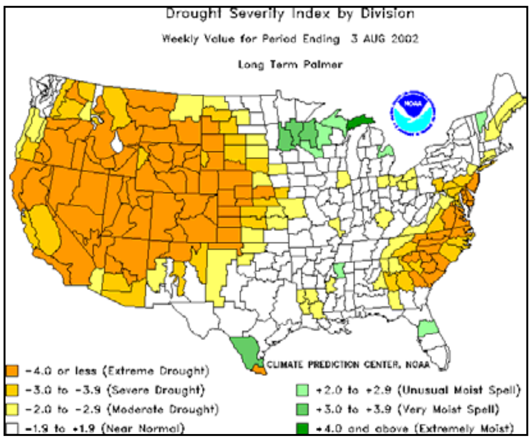


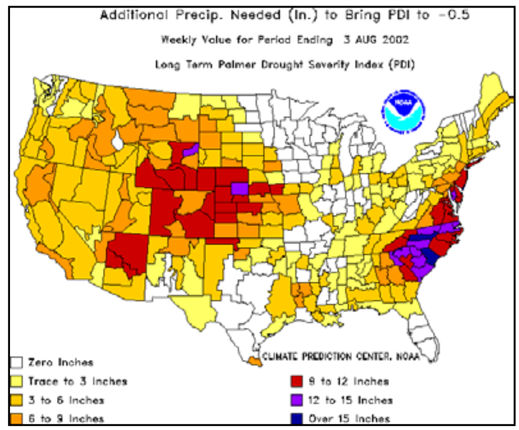


There are four magnitudes of drought outlined in the New Hampshire State Drought Management Plan. These are Alert, Warning, Emergency and the highest being Disaster. Each level has varying responses.

Historical Events

Droughts have been recurring through the past centuries. Normal precipitation for New Hampshire averages 40 inches per year. During 2001 and 2002 New Hampshire experienced its most recent drought. This drought was the 3rd worst on record, exceeded only by the droughts of 1965-1966 and 1941-1942. The maps below, reprinted from a NOAA website, represent the Long Term Palmer conditions for the country in early August of 2002. The map on the left represents the Drought Severity Index, which shows the northern portion of New Hampshire near normal while the southern portion of New Hampshire is still in the moderate drought status. The map on the right represents the additional precipitation needed in a one week period to bring the index back to normal.





Hydrological drought is evidenced by extended periods of negative departures. Four droughts of significant extent and duration were evident in the 20th century as noted below. The drought of 1929-1936 coincided with severe drought conditions in large areas of the central and eastern United States. The most severe drought recorded in New Hampshire occurred from 1960 to 1969. This drought encompassed most of the northeastern United States.

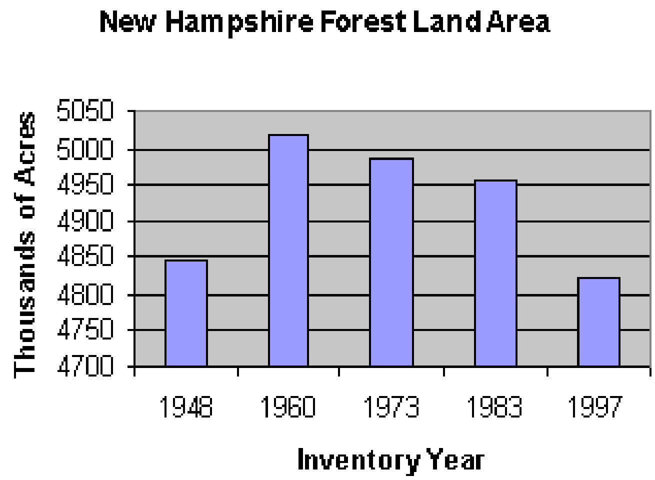
Historically, droughts in New Hampshire have had limited effect because of the plentiful water resources and sparse population. Since 1960 the population has more than doubled, which has increased demand for the State's water resources. Further droughts may have considerable affect on the State's densely populated areas along the seacoast and in the south-central area.

NEW HAMPSHIRE DROUGHT HISTORY			
Dates	**Area Affected**	**Recurrence Interval Yrs**	**Remarks**
1929-1936	Statewide	10 to > 25	Regional
1939-1944	Statewide	10 to > 25	Severe in southeast and moderate elsewhere
1947-1950	Statewide	10 to 25	Moderate
1960-1969	Statewide	> 25	Regional longest recorded continuous spell of less than normal precipitation
2001-2002	Statewide	Not yet determined	Third worst drought on record, exceeded only by the drought of 1956-1966 and 1941-1942

E. Wildfire

General Description

New Hampshire is heavily forested and is therefore vulnerable to this hazard, particularly during periods of drought. The proximity of many populated areas to the State's forested lands exposes these areas and their populations to the potential impact of Wildfire. The Granite State is the second most forested state in the United States (trailing Maine). Forests occupy 84 percent, or 4.8 million acres. The area of forest land has declined by 134,500 acres (2.7 percent) since 1983 and is now about the same as in 1948. Three-fourths of the decline occurred in the southern part of the state, where rapid commercial and residential development has extended into previously forested areas.



Historical Events

Historically, large NH Wildland Fires run in roughly 50-year cycles, which can be observed from the 1800's, including large fires such as one that consumed the entire downtown of Raymond in 1892. In 1915, fires totaling 29,480 acres burned over most of the state, and in 1941, a single large fire in Marlow covered over 25,000 acres. Also in the early 1940's a several thousand acre fire consumed a portion of the Ossipee Plains; this area is now heavily settled with permanent homes which are at tremendous risk of loss due to fire in this high-hazard area of pitch pine and scrub oak. As recently as 1987, a similar fire burned in a combined commercial and residential area in the city of Concord, crossing a two-lane highway as a crown fire.

Summary of State Wildfire Burns

YEAR	AREA OF STATE	ACRES BURNED
1885	*Wild River Area East*	*3,000*
1886	*Zealand Valley*	*12,000*
1888	*Zealand Valley*	*12,000*
1903	Kilkenney (Berlin)	25,000
1903	Wild River (West)	3,000
1903	Zealand Valley	12,000
1907	Swift River	10,000
1908	Pemi Valley Mt. Liberty	4,800
1912	Swift River (Conway)	1,000
1914	Rock Branch (Conway)	10,052
1923	Waterville Valley	3,500
1947	Newbury-Goshen	2,125
1947	Farmington	7,333
1947	Freedom	1,225
1947	Salem	1,518
1953	Tuftonboro	1,794
1953	Enfield	1,595
1984	Table Mountain (Bartlett)	100

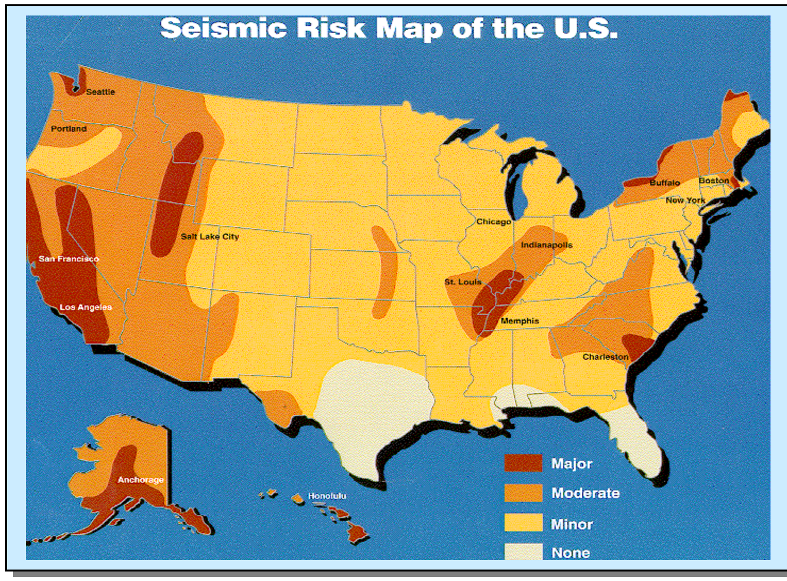
The increased incidence of large Wildland Fire activity in the late 1940s and early 1950s is thought to be associated, in part, with debris from the Hurricane of 1938. Significant woody "fuel" was deposited in the forests during that event. Large fires burned in rural, suburban, and urban areas, including one fire of over 1500 acres in Salem and Atkinson, and numerous large fires in Farmington and Rochester which spread in to southern Maine. Large fire activity continued through the early 1950's, again in the mid-1960's – including a crown fire that spread from Brentwood through Exeter and in to Kensington. Fire activity in the 1970's and '80's when many towns created permanently staffed fire departments to replace volunteers showed a general decrease in total acreage burned, however the total number of fire starts actually increased dramatically.

Present concerns of NHDRED Division of Forest & Lands include the Ice Storm of 1998 which has left a significant amount of woody debris in the forests of the region as may fuel future Wildfires similar to the debris caused by the Hurricane of 1938. Fires in New Hampshire are predominantly human-caused, and roughly half of the total fire activity is in the most populous three southern counties; fires in the northern regions where the population is minimal are complicated by poor access and rugged terrain which greatly hinder efficient and safe response by firefighters. Helicopter support is often needed in such areas, and helicopters are also used on occasion for the fires in the southern tier where wildland fires threaten valuable resources such as residential areas. Local fire departments find an increased need for state personnel, equipment, and technical support from the Division of Forests & Lands as fire numbers and incident complexity increase. While there are over 8,000 firefighters in New Hampshire, these are still predominantly volunteer organizations with roughly 1,000 firefighters belonging to a permanent department in a larger town or city. These volunteer or permanent fire departments generally specialize in structural fire response and emergency medical services, and while early detection of fires has helped to decrease the total acreage burned it is increasingly common for towns to rely on state support for any incident that involves more than just a few acres in size.

In addition to woodland fires, Phragmites Australis is a recognized fire danger in coastal areas. Phargmites is a very tall grass that proliferates in brackish water near the coast. The National Fire Danger Rating System has designated this type of marsh grass as a fire hazard described as "Marsh situations where the fuel is coarse and reed-like. Twenty years ago Phragmites were located in a few isolated pockets, today it covers hundred of acres in New Hampshire's salt marshes The towns of Seabrook and Hampton, NH have recently experienced Phragmites fires as well as neighboring Salisbury, MA. A Seabrook fire in 1996 was started as a controlled burn. However, due to the density of the Phragmites, the fire burned so hot, it melted the vinyl siding off a nearby house. That fire was the impetus for a current Phragmites elimination project at that site funded by the NH Coastal Program. Although, this type of fire has not occurred often in the past, it is becoming more prevalent as Phragmites spreads.

Note the proximity of the growth of this dry plant material with respect to the structures adjacent to the marsh.

F. Earthquake



General Description

Earthquake is defined as a series of vibrations induced in the Earth's crust by the abrupt rupture and rebound of rocks in which elastic strain has been slowly accumulating.

The State is considered to lie in an area of "Moderate" seismic activity with respect to other areas of the United States and is bordered to the North in Canada and Southeast by areas of "Major" activity

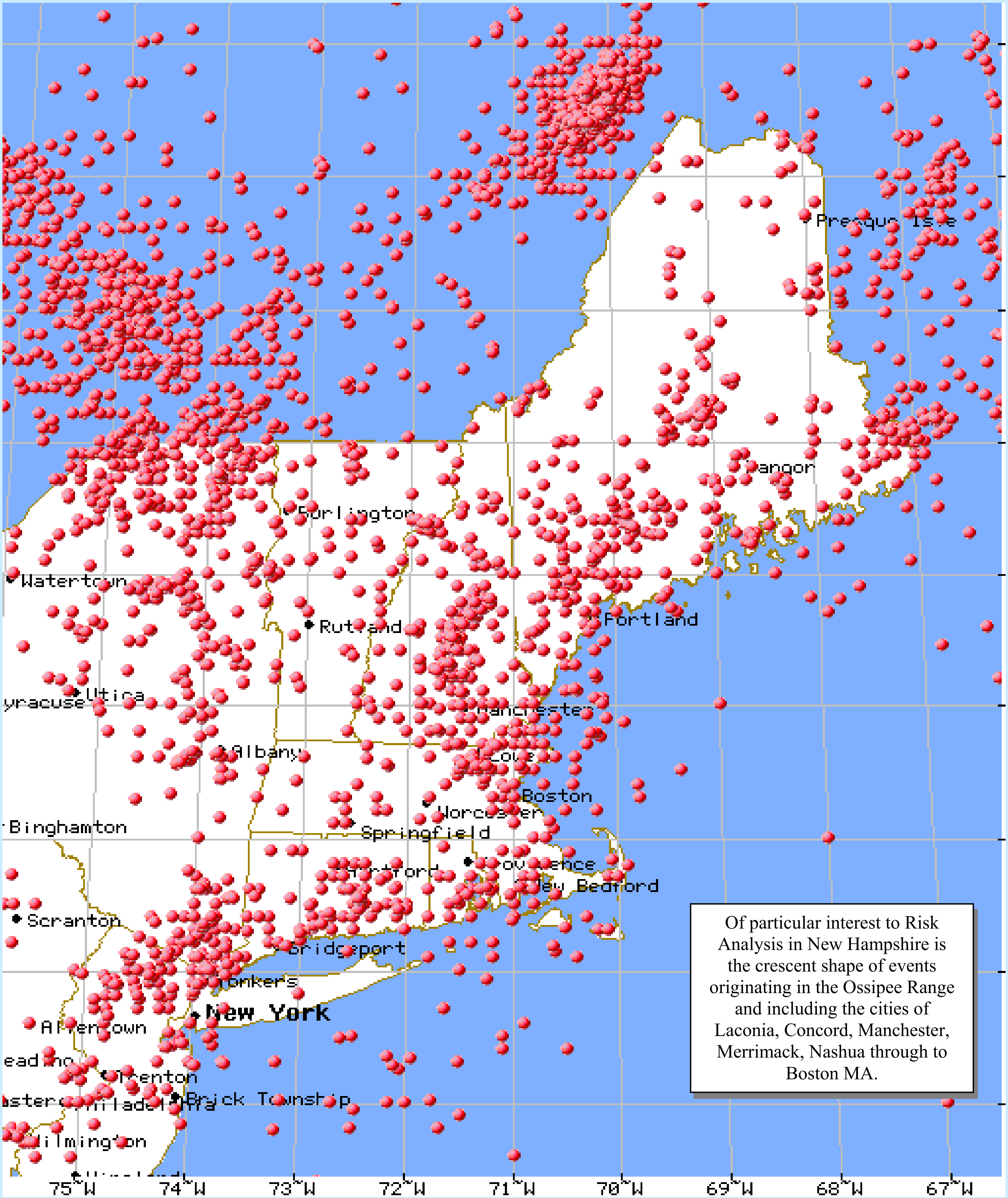
Earthquakes in the Northeastern United States cannot be associated with specific known faults. As opposed to the typical seismic activity evident in California which occurs at, or near the conjunction of two of the Earth's major tectonic plates (or ***"interplate***" events), earthquakes with epicenters in the environs of New Hampshire are instead, referred to as ***"intraplate"*** activity.

Casual factors of this seismicity are, as yet, speculative. Theories which credit North American tectonic plate stresses, coupled with the elastic response of some areas of this plate to the retreating glacier of some 10,000 years ago, are supported by the most recent studies and data as potentially causal.

Historical Events

One of the earliest written accounts of Earthquake activity in North American (from 1638), describes an event which most probably had its epicenter in, or near the Ossipee Range of Central New Hampshire. For an overview of the historical frequency, magnitude and damages associated with New Hampshire's seismic activity to date, the reader is referred to the historical data contained in the synopsis of earthquake events as compiled thus far by the NHBEM. You may visit the following site for more information on New England Earthquakes: http://www.nhoem.state.nh.us/NaturalHazards/naturalhazards.shtm

New England Location	***Date***	***Magnitude***
Ossipee, NH	December 20, 1940	5.5
Ossipee, NH	December 24, 1940	5.5
Dover-Foxcroft, ME	December 28, 1947	4.5
Kingston, RI	June 10, 1951	4.6
Portland, ME	April 26, 1957	4.7
Middlebury, VT	April 10, 1962	4.2
Near NH Quebec Border, NH	June 15, 1973	4.8
West of Laconia, NH	Jan. 19, 1982	4.5

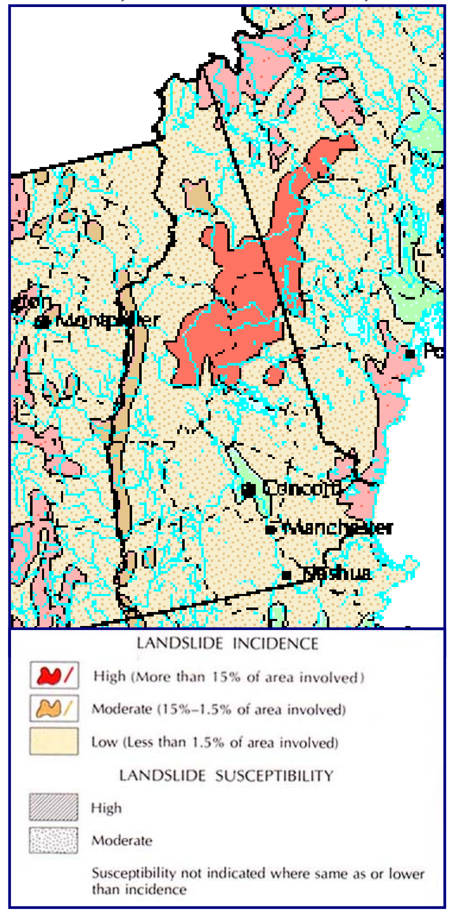


Approximate epicenter of all seismic events in or near the Northeast U.S. from 1638 to 1995

G. Landslide

General Description

A Landslide is the downward or outward movement of slope forming materials reacting under the force of gravity including: mudflows, mudslides, debris flows, rockslides, debris avalanches, debris slides and earth flows. Landslides may be formed when a layer of soil atop a slope becomes saturated by significant precipitation and slides along a more cohesive layer of soil or rock. Seismicity may play a role in the mass movement of landforms, such as was reported in Newcastle, NH and Berlin, MA during the Cape Ann event of 1755.



New Hampshire, although mountainous, consists largely of relatively "old" geologic formations that have been worn by the forces of nature for eons prior to the arrival of the Europeans. Consequently, much of the landscape is relatively stable and the exposure to this hazard type is generally limited to recreational and sparsely populated areas in the North and North Central portion of the State. Formations of sedimentary deposits and along the Connecticut and Merrimack Rivers also create potential landslide conditions. *(See Map to the right).*

Historical Events

Although the Vulnerability to Landslide activity statewide is generally modest, the reader should be aware that the State has considerable terrain that is susceptible to Landslide action. Along the roadside in the area known as Crawford Notch on Route 302 in the White Mountain National Forest, appears an historical maker documenting a farm family who perished in a landslide event. In most recent events, the historic "Old Man of the Mountain" fell prey to a natural landslide event.

(Photo of the Old Man 2000)

The Old Man of the Mountain, the enduring symbol of the State of New Hampshire, is no more. Some time between the evening of Friday, May 2, 2003 and the morning of Saturday, May 3, 2002, the stone profile that draws hundreds of thousands of visitors to Franconia Notch State Park each year collapsed. On Saturday, May 3 at approximately 7:30 a.m., two Franconia Notch State Park employees noticed that the Old Man of the Mountain had collapsed. The continuous action upon the seemingly solid rock of the freezing and thawing of the moisture which invades the rock's fissures causes the rock to split and separate as the formed ice expands. As this action occurs repetitively on the steeply sloped areas of the State, eventually the land will succumb to the force of gravity. An accumulation of this relatively loose debris may eventually become unstable en mass and form a landslide.

(View After the Rock Slide May 3, 2003)

Given the proximity of these landslide vulnerable areas to the areas of relatively high seismicity originating form nearly due north in the St. Lawrence River Basin, as well as those events originating in the Ossipee Mountain Range, coupled with the relatively high incidence of flooding in these areas with associated saturated soil conditions. Consideration must be given to the vulnerability of man-made structures in these areas to seismicity and/or soils saturation induced landslide activity.

Losses going to this hazard type are often attributed to other related events. During a recent Flood event (FEMA DR-1231-NH) a death occurred when a mass of saturated soil collapsed taking a man's life. The death was attributed to the declared Flood event.

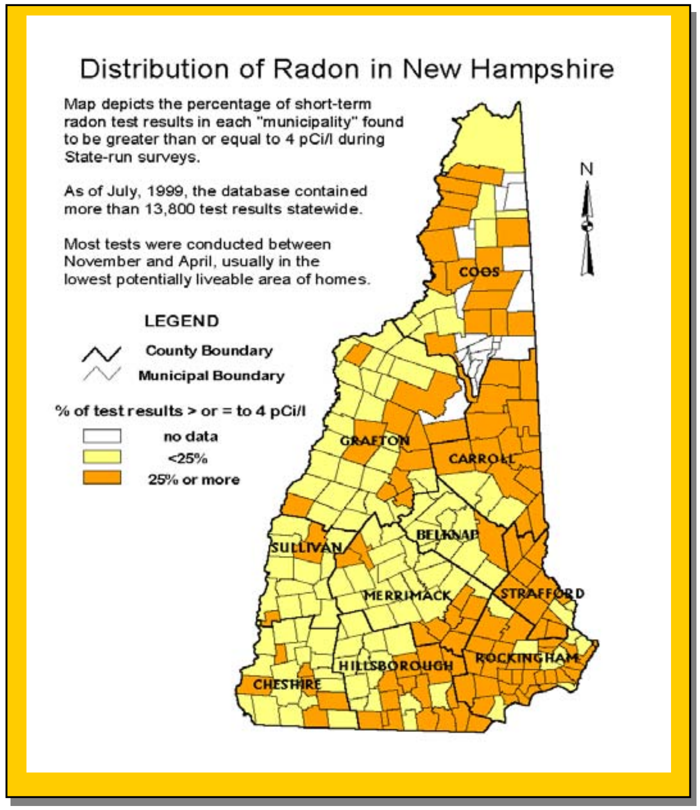
H. Radon

General Description[2]

A naturally occurring radioactive gas with carcinogenic properties is a common problem in many states; New Hampshire is one of them. Radon can be associated with some of the granite rock in New Hampshire. Whether or not a particular type of granite emanates radon is dependent on the geochemistry of that particular granite, some are a problem and some are not. In other parts of the country, radon is associated with certain black shales, sandstones and even limestones. EPA has estimated that radon in indoor air is responsible for about 13,600 lung cancer deaths in this country each year (EPA document, EPA 811-R-94-001, 1994).

Historical Events

Radon is not a singular event rather a natural hazard that can take years and decades in order to see the effects. Most recent data collected by the NH Office of Community and Public Health's Bureau of Radiological Health in 2003 indicates that one third of the houses in New Hampshire have indoor radon levels that exceed the US Environmental Protection Agency's "action level" of **four picocuries per liter for at least some** portion of the year. Measured values exceeding 100 pCi/l have been recorded in at least eight of New Hampshire's ten counties. The highest indoor radon reading in New Hampshire of which Bureau staff is aware is greater than 900 pCi/l, higher values probably exist (see adjacent map). The table below reflects only data collected as part of state-run surveys and in no way should be considered to represent the full range of values found in the respective counties.



Summary Table of Short-term Indoor Radon Test Results in NH's Radon Database (5/7/99)

COUNTY	# of Tests	†G. Mean	‡Maximum	% > 4.0 pCi/l	%>12.0 pCi/l
Belknap	744	1.3	22.3	14.1	1.3
Carroll	1,042	3.5	478.9	45.4	18.0
Cheshire	964	1.3	131.2	15.6	2.3
Coos	1,072	3.2	261.5	41.0	17.0
Grafton	1,286	2.0	174.3	23.2	5.2
Hillsborough	2,741	2.1	202.3	29.6	6.8
Merrimack	1,961	2.0	152.8	25.2	6.0
Rockingham	3,909	3.0	155.3	40.0	9.5
Strafford	1,645	3.4	122.8	44.0	13
Sullivan	466	1.4	29.4	15.7	2.1
STATEWIDE	**15,860**	**2.4**	**478.9**	**32.4**	**8.6**

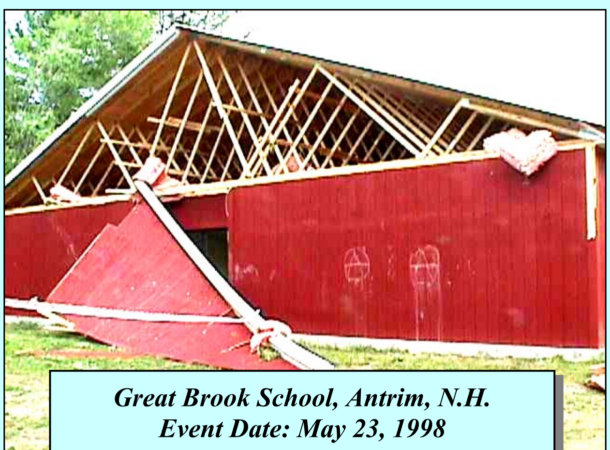
[2] All radon information provided by the NH Office of Community and Public Health

I. Tornado & Downburst

General Description

A tornado is a violent windstorm characterized by a twisting, funnel shaped cloud. These events are spawned by thunderstorms and, occasionally by hurricanes, and may occur singularly or in multiples. They develop when cool air overrides a layer of warm air, causing the warm air to rise rapidly. Most vortices remain suspended in the atmosphere. Should they touch down, they become a force of destruction.

A downburst is a severe localized wind blasting down from a thunderstorm. These "straight line" winds are distinguishable from tornadic activity by the pattern of destruction and debris. Depending on the size and location of these events, the destruction to property may be devastating. Downbursts fall into two categories: *Microburst* which covers an area less than 2.5 miles in diameter; and *Macroburst* which covers an area at least 2.5 miles in diameter.



Great Brook School, Antrim, N.H.
Event Date: May 23, 1998

Historical Events

In 1998 a F2 A tornado in Antrim, N.H. blew down a 45-foot by 12-foot section of the Great Brook Middle School, officials said. Witnesses reported seeing a funnel cloud, and the weather service after an inspection confirmed it was a tornado. According to the June 2, 1998 edition of the Eagle Tribune, John Jensenius from the National Weather Service in Gray, Maine said "He estimated the twister cut a path half a mile long, up to 100 yards wide, and was on the ground for several minutes."

NH Tornado History
1950 - 2003

County	Date	Fujita Scale
Belknap	July 3, 1972	F2
Belknap	July 23, 1995	F1
Belknap	July 6, 1999	F1
Carroll	July 18, 1963	F2
Cheshire	September 15, 1922	F2
Cheshire	September 13, 1928	F2
Cheshire	August 13, 1963	F2
Cheshire	June 6, 1969	F2
Cheshire	July 3, 1997	F1
Coos	May 5, 1929	F2
Grafton	August 20, 1816	
Grafton	September 9, 1821	
Grafton	July 16, 1880	F2
Grafton	August 11, 1966	F2
Grafton	May 11, 1973	F2
Grafton	August 13, 1999	F1
Hillsborough	July 28, 1748	
Hillsborough	May 21, 1814	
Hillsborough	September 15, 1922	F2
Hillsborough	July 2, 1961	F2
Hillsborough	June 9, 1963	F2
Hillsborough	July 19, 1966	F2
Hillsborough	July 17, 1968	F2
Hillsborough	August 20, 1968	F3
Hillsborough	July 3, 1997	F2
Hillsborough	May 23, 1998	F2
Merrimack	July 14, 1791	
Merrimack	September 5, 1792	
Merrimack	July, 1793	
Merrimack	July 24, 1911	F2
Merrimack	July 6, 1999	F1
Rockingham	May 21, 1814	
Rockingham	May 16, 1890	F2
Rockingham	August 21, 1951	F2
Rockingham	June 9, 1953	F3
Rockingham	June 19, 1957	F2
Rockingham	July 2, 1961	F2
Rockingham	June 9, 1963	F2
Strafford	May 17, 1773	
Strafford	August 15, 1787	
Strafford	May 14, 1963	F2
Strafford	May 3, 1976	F2
Strafford	June 22, 1981	F2
Strafford	July 6, 1999	F2
Sullivan	May 23, 1782	
Sullivan	September 9, 1821	
Sullivan	July 1, 1831	
Sullivan	August 13, 1999	F1

Downburst activity is very prevalent throughout the State. However, the majority of them go mostly unrecognized unless a large amount of damage has occurred. Several of the more significant and recent events are highlighted on the following page.

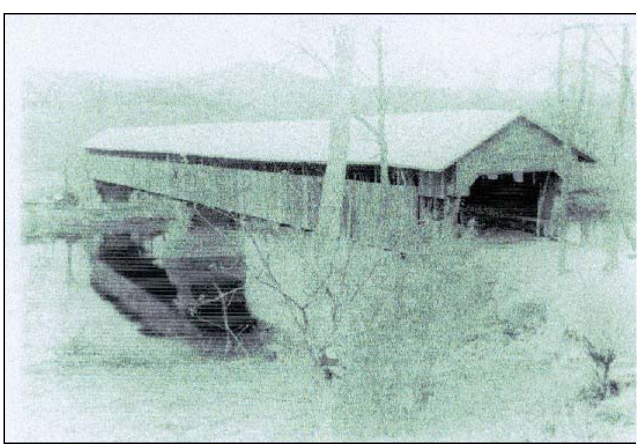
Location	Central NH
Counties	Merrimack, Grafton, Hillsborough
Event Date	July 6, 1999
Event Type	Macroburst
Fatalities	2
Damages	2 roofs blown off structures, downed trees, widespread power outages, and damaged utility poles & wires.

Microburst Damage in Moultonborough

Location	Town of Stratham
County	Rockingham
Event Date	August 18, 1991
Event Type	Microburst
Injuries	11
Fatalities	5
Cumulative Damages	$ 2,498,974

Location	Moultonborough
County	Carroll
Event Date	July 26, 1994
Event Type	Microburst
Scope of Event	½ mile wide 4-6 mi in length
Damages	Downed trees, utility poles and wires 1800 homes without power, and 50 – 60 houses damaged

In addition to the above wind incidents, in 1979 a “mighty windstorm” destroyed the newly renovated Bedell covered bridge in Haverhill, NH. The stone marker at the site reads: “Destroyed in a mighty windstorm on September 14, 1979. This had been the longest Two-Span Arch Truss left in America. Closed to traffic by wind damage in 1958 and due to be demolished n 1973, it was restored during a six-year program by Bedell Covered Bridge Inc. and reopened on July 22, 1979.”



Restored Bedell Bridge, Haverhill, NH, July 1979
Photo courtesy of Glen English

Bedell Bridge, Haverhill, NH, September 1979
Photo courtesy of Glen English

J. Hurricane

General Description

A hurricane is a heat engine that derives its energy from ocean water. These storms develop from tropical depressions which form off the coast of Africa in the warm Atlantic waters. When water vapor evaporates, it absorbs energy in the form of heat. As the vapor rises, it cools within the tropical depression, and then condenses, releasing heat, which sustains the system.

Hurricanes Impacting on New Hampshire
1635 - 1991

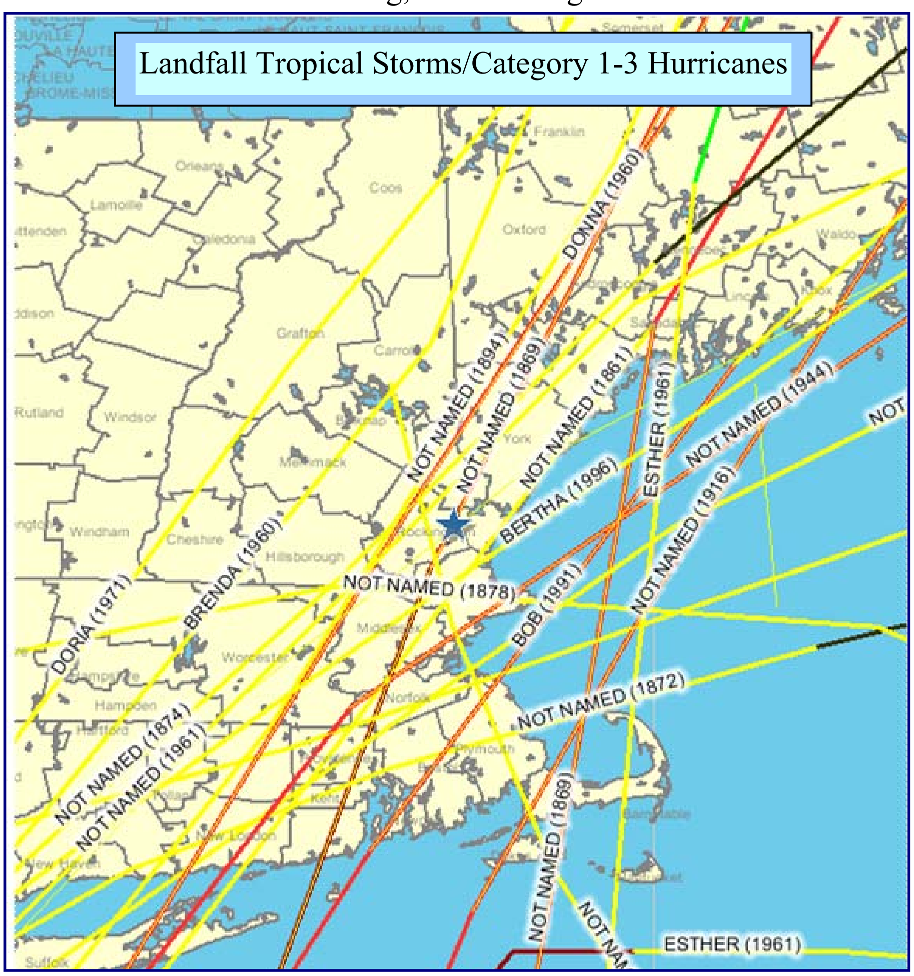
Name	Event Date	Wind Speed
Hurricane of 1635	August, 1635	
Hurricane of 1778	October 18-19, 1778	40 – 75mph
Hurricane of 1804	October 9, 1804	
Gale of 1815	September 23, 1815	>50 mph
Hurricane of 1869	September 8, 1869	
Hurricane of 1938	September 21, 1938	186 mph (max)
Hurricane Carol	September, 1954	
Hurricane Donna	September, 1960	
Hurricane Gloria	September 28,1985	>70 mph
Hurricane Bob	August, 1991	>60 mph
Hurricane Floyd		

Coastal Storms

The State's Atlantic seacoast and estuaries are vulnerable to extremes in stormwater runoff and storm surge from coastal storms and hurricanes. Storm surge from these events, especially when coupled with astronomical high tides, presents a threat to all land areas adjacent to the marine environment. The State's erosion threat is moderate as compared to some neighboring coastal states. The conditions with respect to this hazard and all natural coastal related hazards are monitored by the NH Office of State Planning, Coastal Program

Historical Events

As can be seen from the map to the right, New Hampshire's exposure to direct and indirect impacts from hurricanes is real, but modest, as compared to other states in the region. The most devastating recorded hurricane impact on New Hampshire occurred in September, 1938. The storm drove through the heart of southern New England after devastating Providence Rhode Island and leaving some 600 dead in the Northeast. The Southwest corner of the State experienced the brunt of that event but, according to most hurricane track paths, damage is more likely to occur on, or near the seacoast, and in the Southeast portion of the State.



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K. Lightning

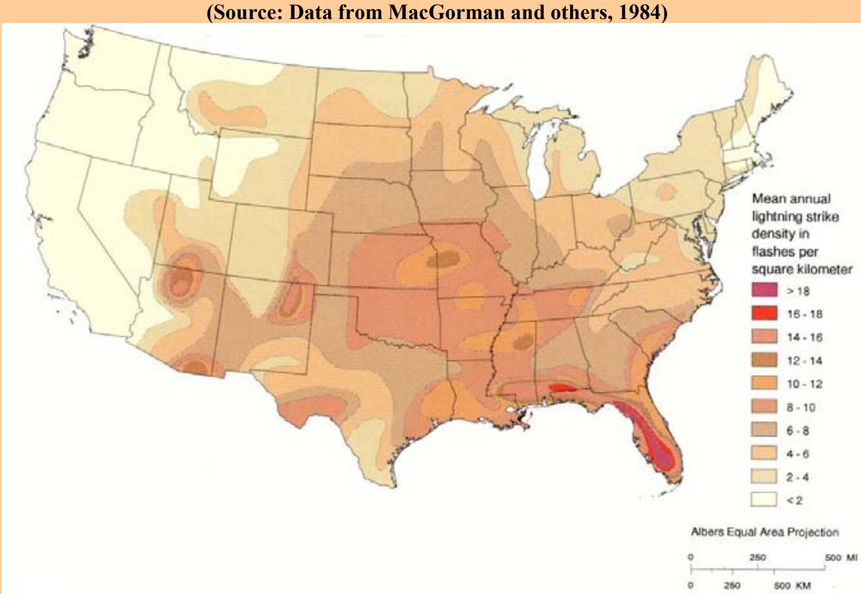
General Description

By definition, all thunderstorms contain lightning. Lightning is a giant spark of electricity that occurs within the atmosphere or between the atmosphere and the ground. As lightning passes through the air, it heats the air to a temperature of about 50,000 degrees Fahrenheit, considerably hotter than the surface of the Sun. During a lightning discharge, the sudden heating of the air causes it to expand rapidly. After the discharge, the air contracts quickly as it cools back to ambient temperatures. This rapid expansion and contraction of the air causes a shock wave that we hear as thunder, a shock wave that can damage building walls and break glass.

Lightning kills an average of 87 people per year in the United States and New Hampshire has the 16^{th} highest casualty rate in the nation (Maine is 8^{th}).

Areal Extent & Severity of Lightning Hazard in the U.S.

(Source: Data from MacGorman and others, 1984)



FEMA Publication, Multi Hazard Identification and Risk Assessment

Photo: Dave Gammon, Lake Winnisquam, Laconia, NH, July, 1999

Historical Events

We are fortunate in Northern New England to have less lightning than most other areas of the country. On average, much of New Hampshire and Maine have less than 2 cloud to ground lightning strikes per square mile per year. Only several states in the Western U.S. have lightning flash density rates as low. In comparison, many states in the Midwest and South have flash density rates of 10 flashes per square mile per year, and, parts of Florida experience flash rates of 30 flashes per square mile per year!!

Despite the relatively low incidence of lightning in New Hampshire and Maine, these states have relatively high casualty rates (combined injury/death rate) due to lightning. New Hampshire ranks 16^{th} in the nation, while Maine ranks 8^{th}!

While there are several factors contributing to this high rate, residents and visitors to Northern New England are likely to be more vulnerable to being struck by lightning because of the activities with which they are involved, particularly on those warm summer days when lightning is most likely to occur. Often, many people are outside enjoying the variety of recreational activities that attract people to Northern New England during the summer when the vulnerability to lightning strike is highest.

L. Severe Winter Weather

General Description

Severe winter weather in New Hampshire may include heavy snow storms, blizzards, nor'easters, and ice storms. Generally speaking, New Hampshire will experience at least one of these hazards during any winter season. A heavy ***snowstorm*** is generally considered to be one that deposits four or more inches of snow (or 10 cm) in a twelve-hour period. A ***blizzard*** is violent snowstorm with winds blowing at a minimum speed of 35 miles (56 kilometers) per hour and visibility of less than one-quarter mile (400 meters) for three hours. A ***Nor'easter*** is a large weather system traveling from south to north, passing along the coast. As the storm's intensity increases the resulting counterclockwise winds that impact the coast and inland areas in a Northeasterly direction. Winds from a Nor'easter can meet or exceed hurricane force winds. ***Ice Storms*** occur when a mass of warm moist air collides with a mass of cold arctic air. The less dense warm air will rise and the moisture may precipitate out in the form of rain. When this rain falls through the colder more dense air and comes in contact with cold surfaces, ice will from and may continue to from until the ice is as thick as several inches.

Historical Events

During the years from 1955 through 1985, a number of winter storms have attained historic stature in the Northeast. The blizzards of February 1958 and January 1966, the triple snowstorms of the 1960/1961 winter, the great New England Blizzard of February 1978, the "Presidents' Day Storm" of February 1979, and a snowstorm with over 20' of accumulation in February 1983 are the most notable events of this period. See Appendix C for a complete history of snowfall events.

Berlin, NH - One fatality and several injured due to collapse from heavy snow

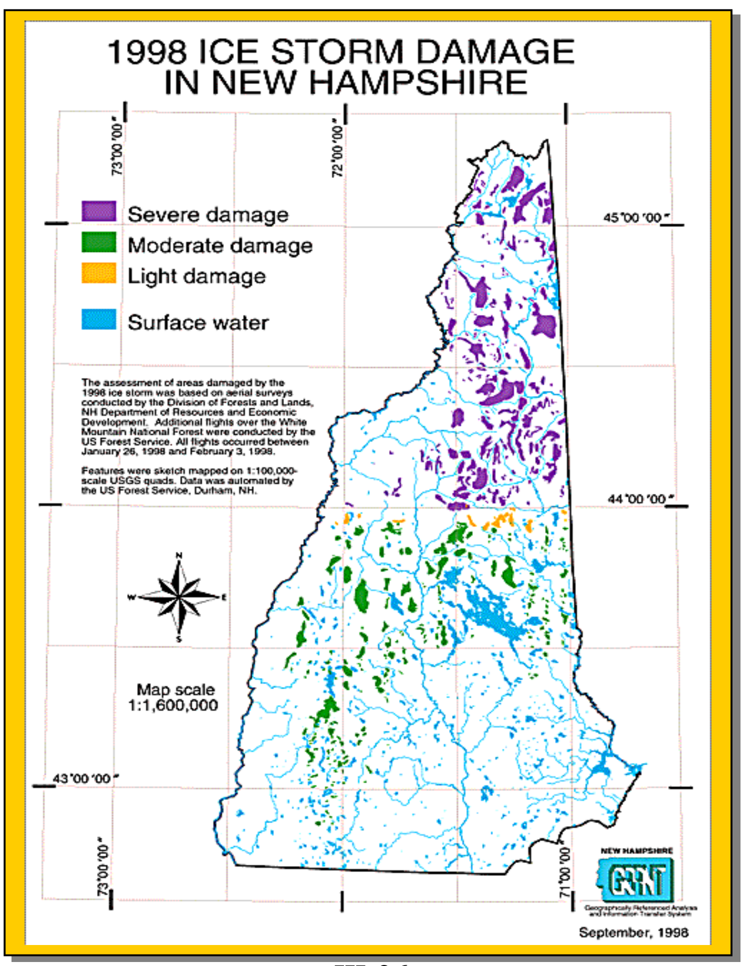
New Hampshire has also experienced several severe Ice Storms as identified below:

- **January 15, 1998**
- Severe ice storm that spread throughout New England causing major damage to private and public utilities.
- **March 3-6, 1991**
- Numerous outages from ice-laden power lines in southern NH.
- **February 14-15, 1986**

- Fiercest ice storm in 30 years in the higher elevations in the Monadnock region. It covered a swath about 10 miles wide from the Massachusetts border to New London, New Hampshire.
- **January 8-25, 1979**
- Major disruptions to power and transportation
- **December 17-20, 1929**
- Unprecedented disruption and damage to telephone, telegraph and power system.

The recent Federal Declared Disaster (DR-1199-NH) Ice Storm of January 1998 was not unique in either its spatial scope or its devastating consequences. A similar event in 1929 is believed to have been comparable to this event. The 1998 event experienced 52 communities in nine counties impacted, six injuries and one fatality, 20 major roads closures, 67,586 without electricity, 2,310 without phone service, one communication tower failure and $17+ million in damages to Public Service of NH alone.

New London, NH - DebrisCleared from 1998 Ice Storm



M. Snow Avalanche

General Description[3]

A snow avalanche is a slope failure consisting of a mass of rapidly moving, fluidized snow that slides down a mountainside. The flow can be composed of ice, water, soil, rock and trees. The amount of damage depends on the type of avalanche, the composition and consistency of the material contained in the avalanche, the velocity and force of the flow and the avalanche path. Natural and human induced Snow Avalanches most often result from structural weaknesses. They are caused by changes in the type and thickness of the snow cover layer resulting from thermal fluctuations or multiple snowfall events. The potential for Snow Avalanches increases with significant temperature influences, which cause metamorphic crystal change in the snow layer, and with the accumulation of dry and wet snow over time.

Snow Avalanches occur on slopes averaging from 25 to 50 degrees, the majority occurring on slopes of from 30 to 40 degrees. They are triggered by natural events such as thermal changes, blizzards, and seismic activity and by human activity such as that of skiers, hikers, snowmobilers, and elastic sound waves such as those created by explosions.

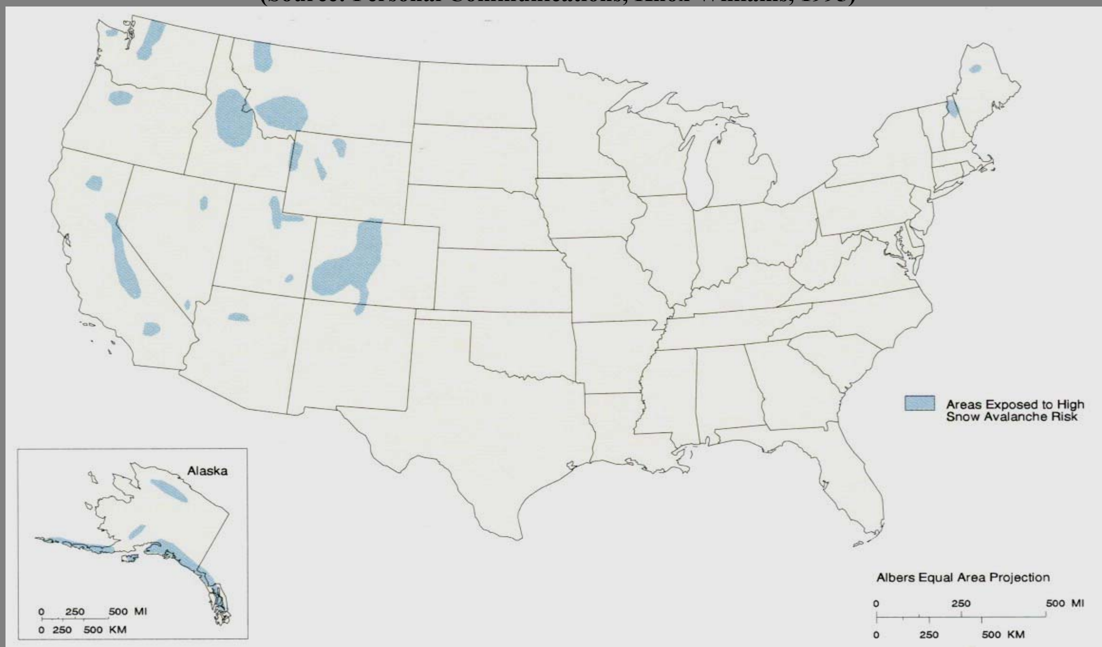
Historical Events

Snow Avalanches are not considered a major natural hazard nationally given the relatively limited geographic areas vulnerable to the effects of this type of event, the proximity of population centers to vulnerable areas and the seasonal nature of the vulnerability in most regions. However, Northern New Hampshire is an area with particularly vulnerable areas (See Map on following page). Over the past 140 years, at least 10 deaths and many significant injuries have been documented in the Presidential Range and elsewhere due to snow avalanches and related causes.

[3] This section contains data from the FEMA publication Multi Hazard, Identification and Risk Assessment

US Avalanche Vulnerability

(Source: Personal Communications, Knox Williams, 1995)



FEMA Publication, Multi Hazard Identification and Risk Assessment